

# Investigation of Cloud Phase Retrieval from AVHRR/3 Reflectance

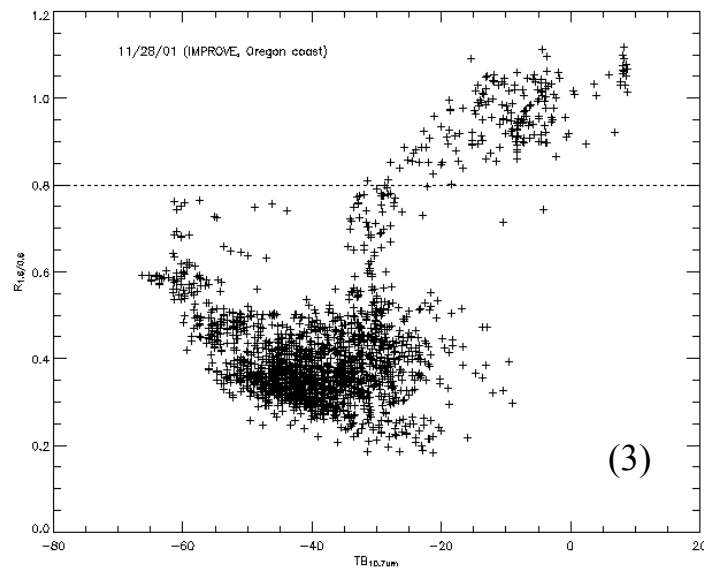
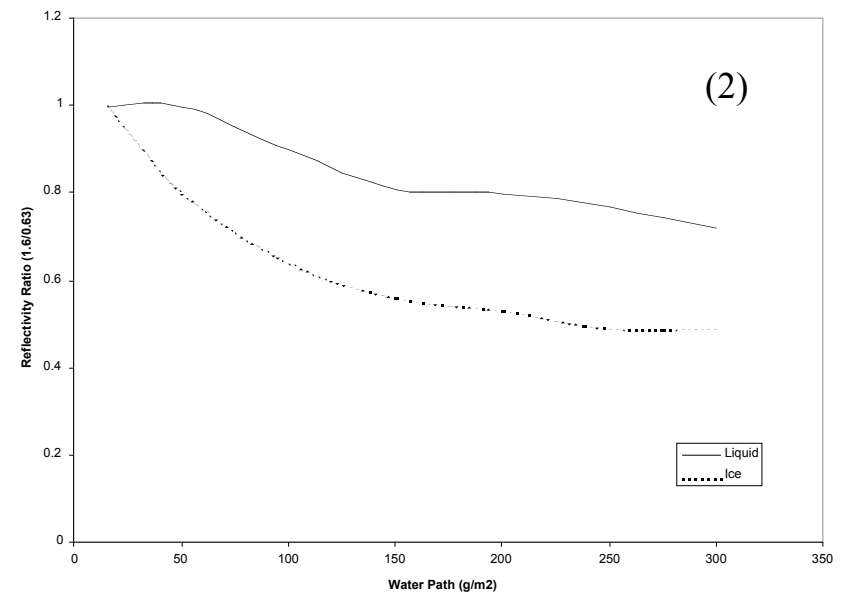
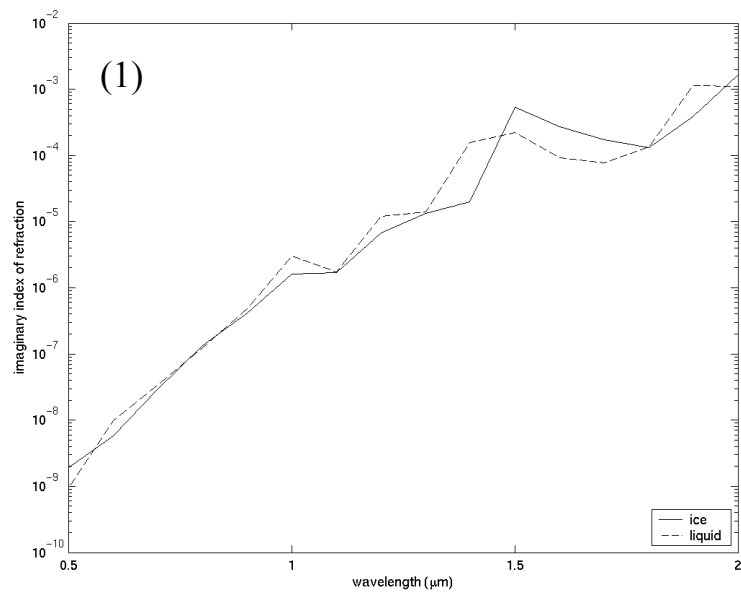
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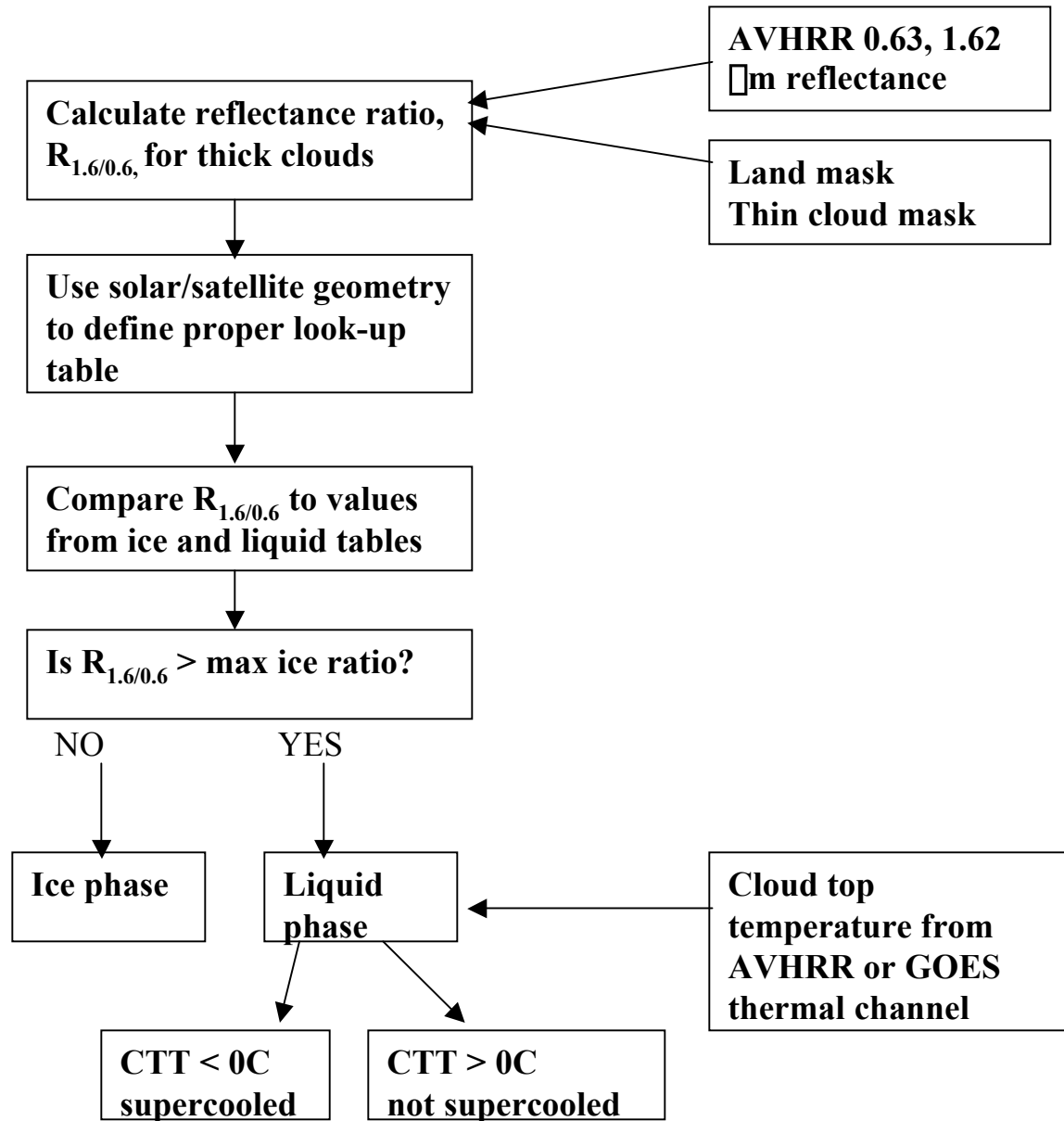
# Method

- Based on differences in refractive indices of ice and water at 1.6  $\mu\text{m}$
- Ratio of reflectance at AVHRR channels 1 and 3a (0.63 and 1.62  $\mu\text{m}$ ) is used as an indicator of thermodynamic phase
- Threshold for ratio depends on solar-satellite geometry and effective radius
- Ambiguities may arise from overlying thin cirrus and highly reflective surfaces

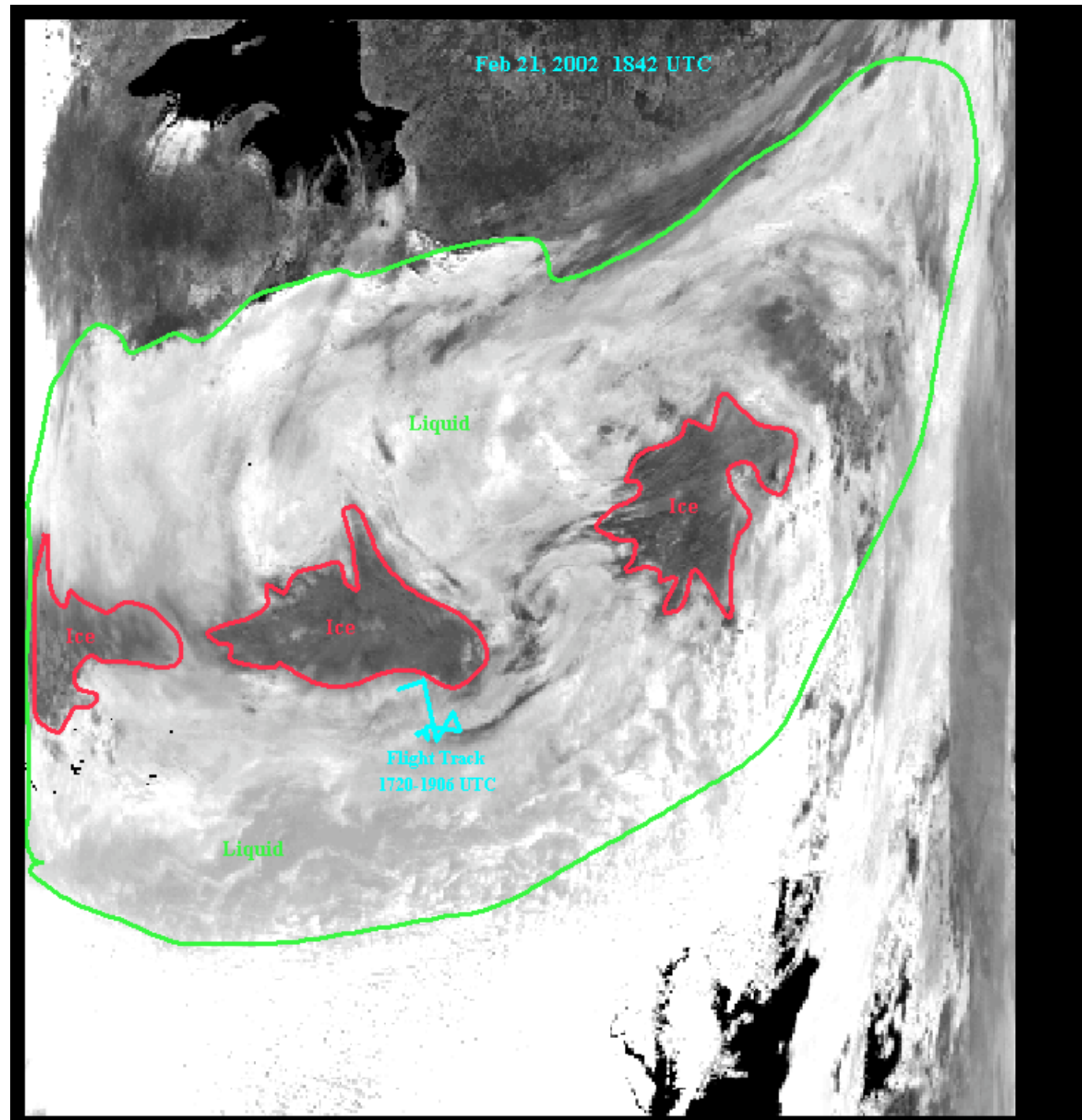


1. Imaginary part of refractive index of liquid and ice
2. Modeled reflectance ratio for a hypothetical cloud
3. Measured reflectance ratio vs. cloud top temperature

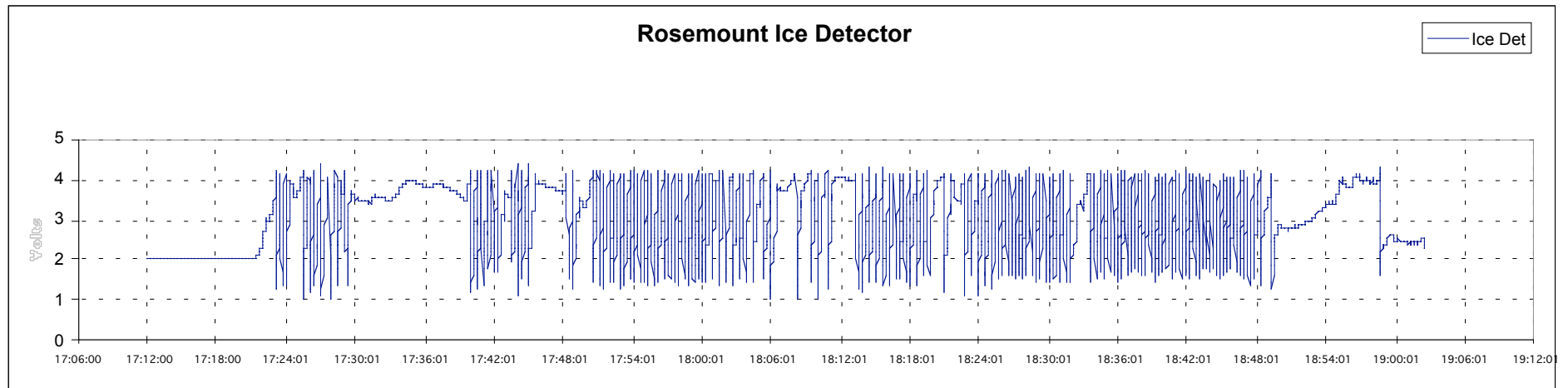
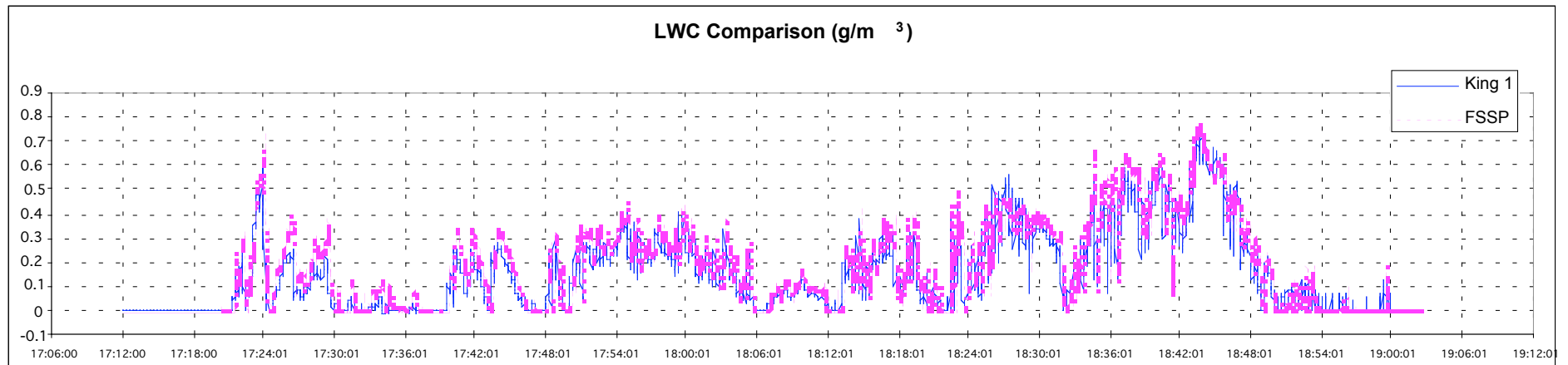
## Phase Classification Decision Tree



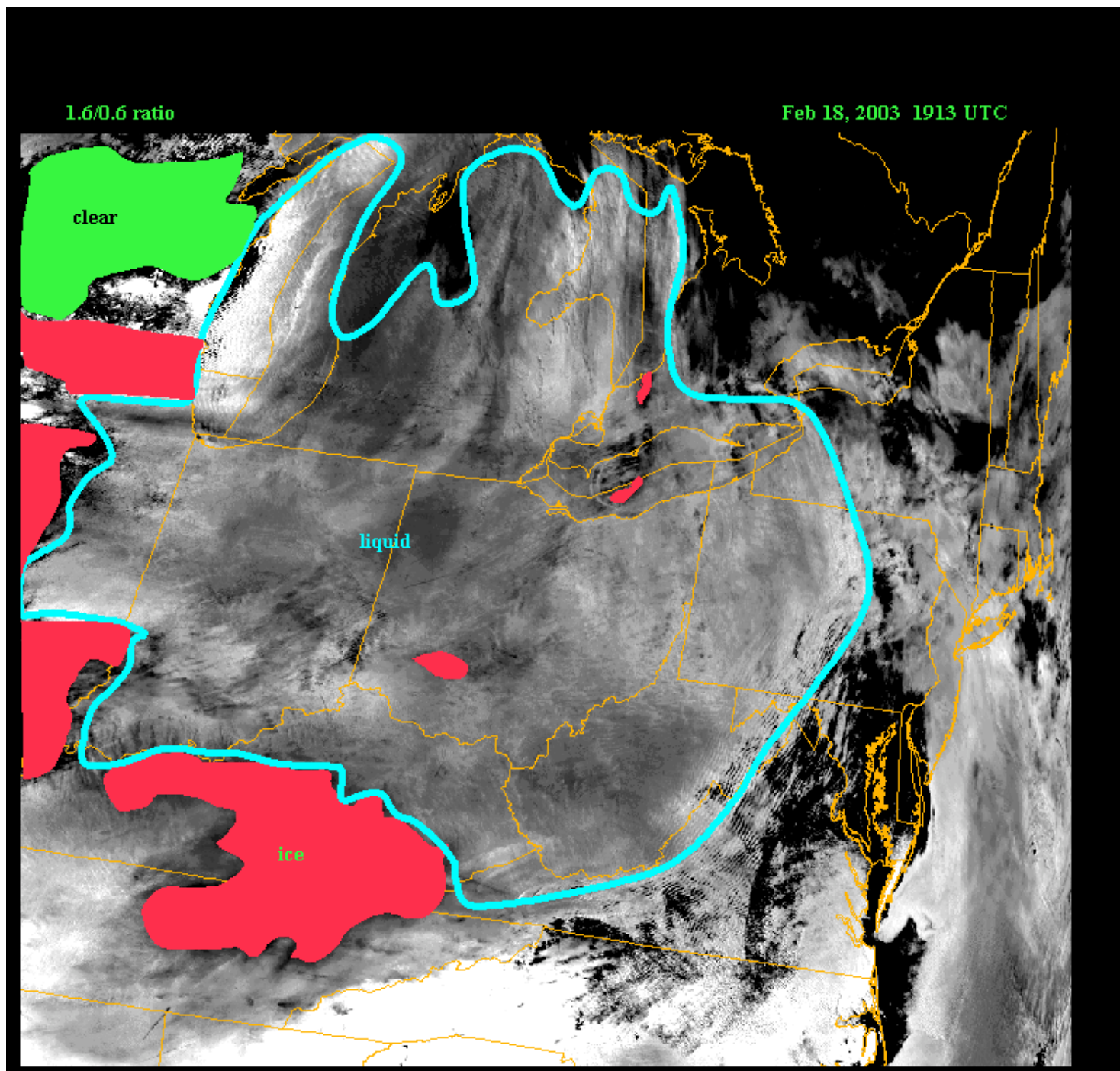
Supercooled liquid  
observations by  
the NASA Twin  
Otter on Feb 21,  
2002



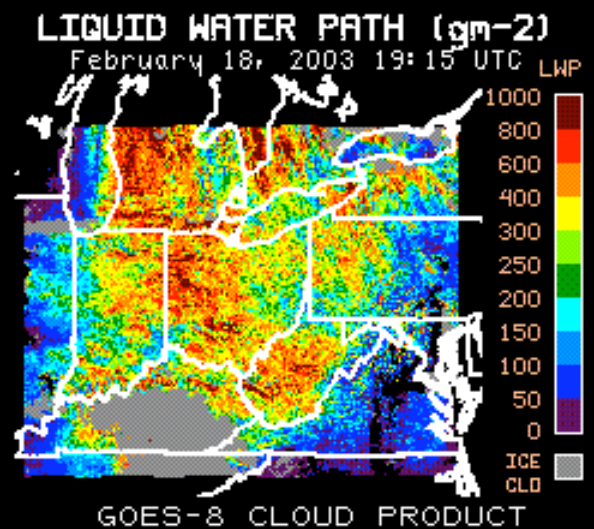
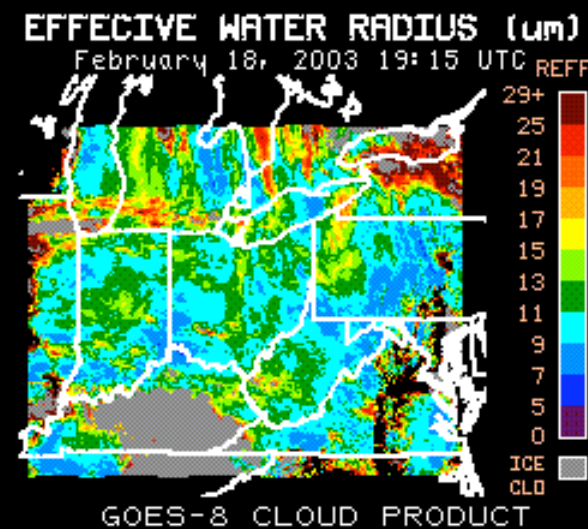
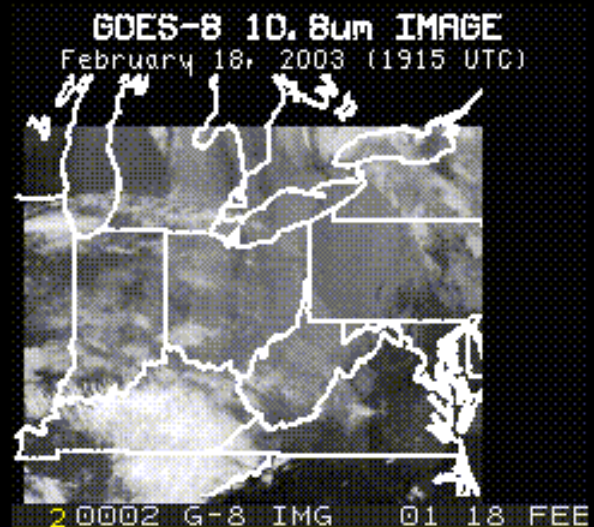
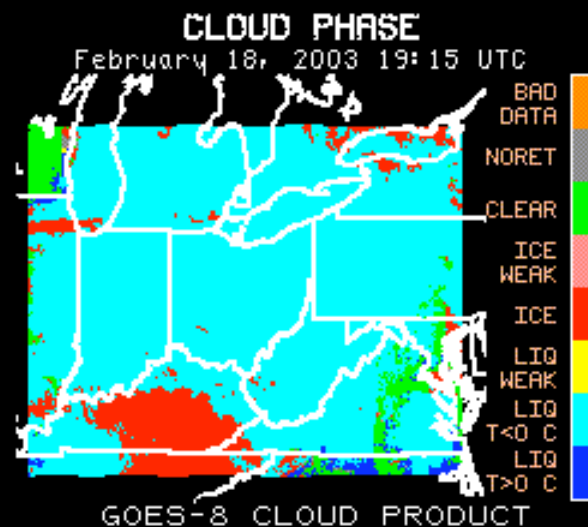
# Twin Otter Liquid Water Measurements on Feb 21, 2002



Reflectance ratio  
corresponding to  
Twin Otter flight  
on Feb 18, 2003

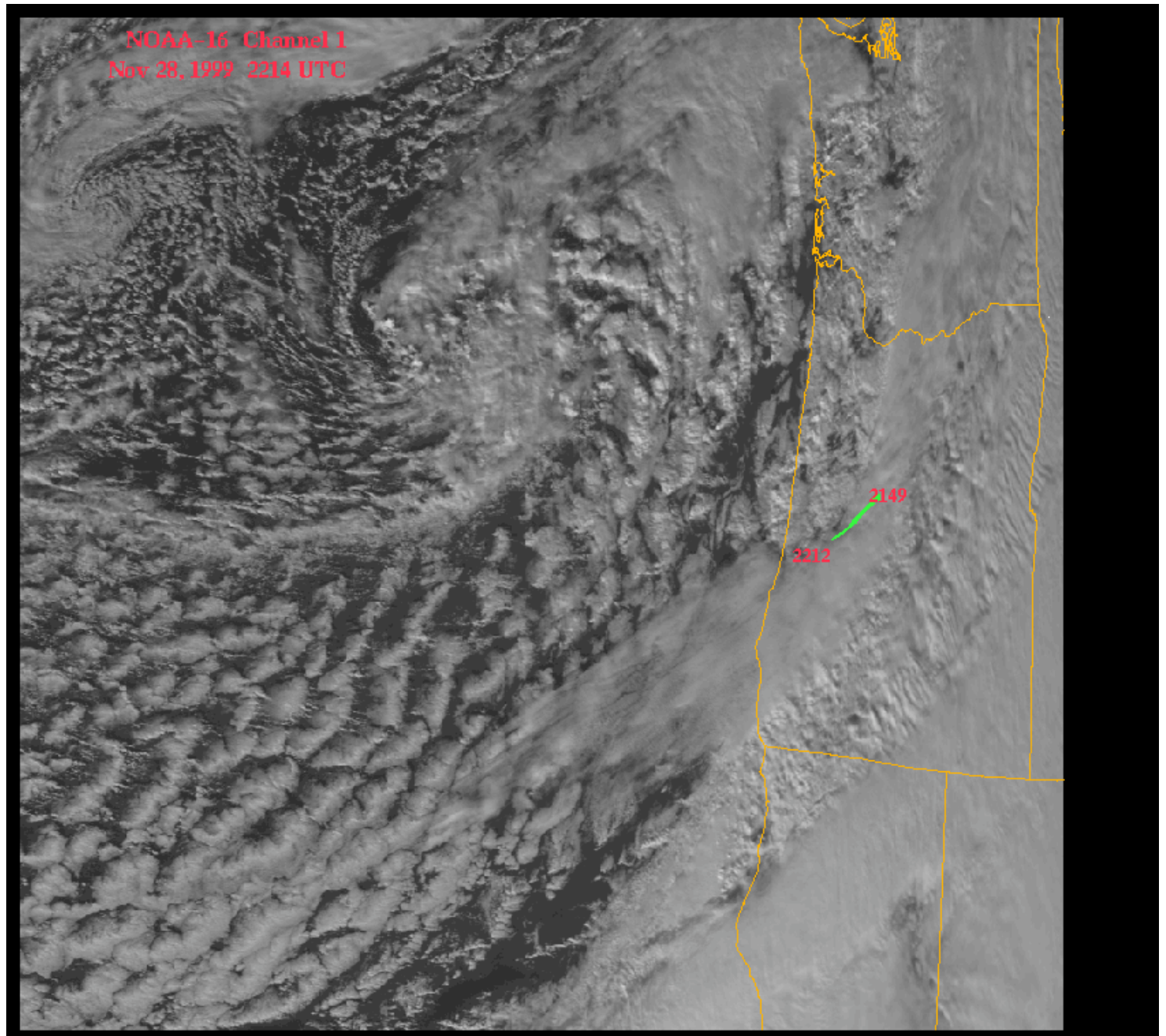


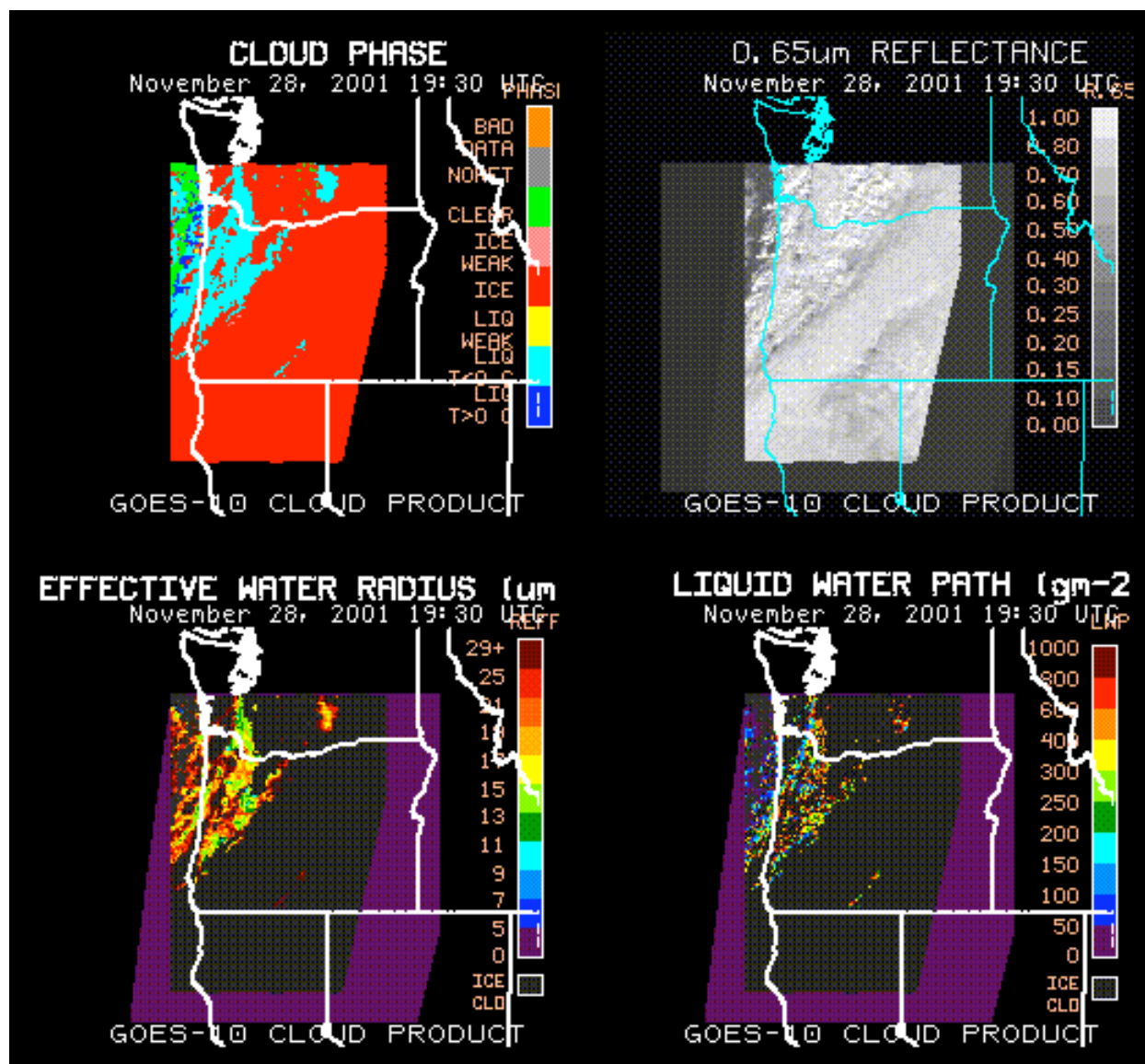






Icing conditions  
observed by the  
UW Convair  
during  
IMPROVE-II







# **AVHRR reflectance ratio look-up tables**

(values based on NASA-Langley database)

## Angles

Solar zenith –  $\mu_0 = 1, 0.95, 0.85, \dots, 0.05$

Satellite zenith –  $\mu = 1, 0.9, 0.8, \dots, 0.1$

Solar/satellite relative azimuth –  $\phi = 0, 7.5, 15, 30, 45, \dots, 165, 172.5, 180^\circ$

## Wavelengths

$\lambda = 0.63, 1.62, 3.7 \mu\text{m}$

## Particle size

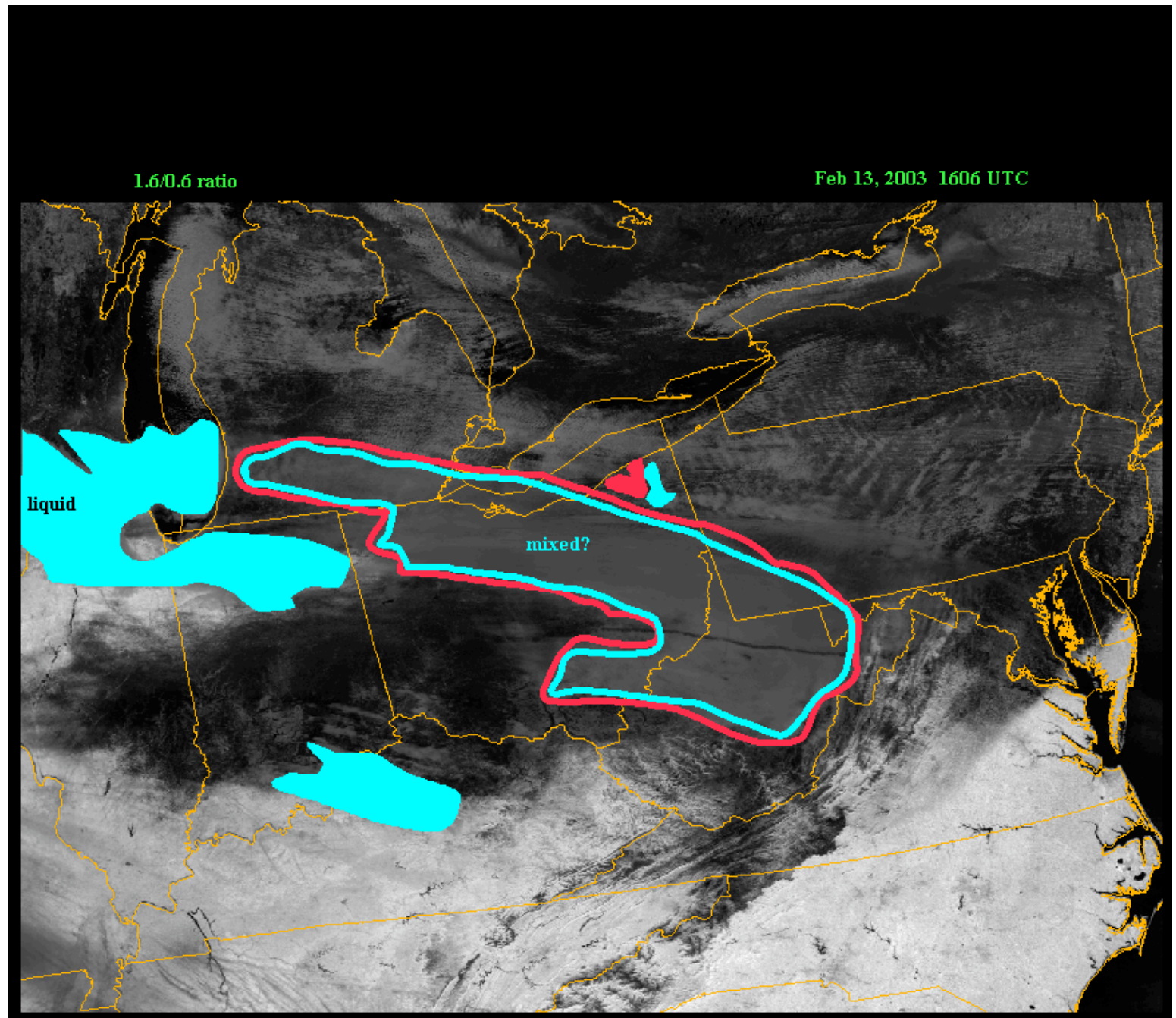
Liquid –  $r_e = 2, 4, 6, 8, 12, 16, 32 \mu\text{m}$

Ice –  $D_e = 6, 18, 24, 30, 45, 75, 105, 123, 135 \mu\text{m}$

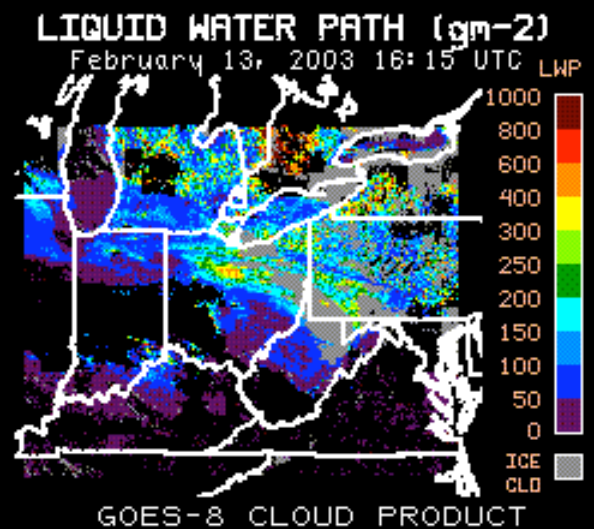
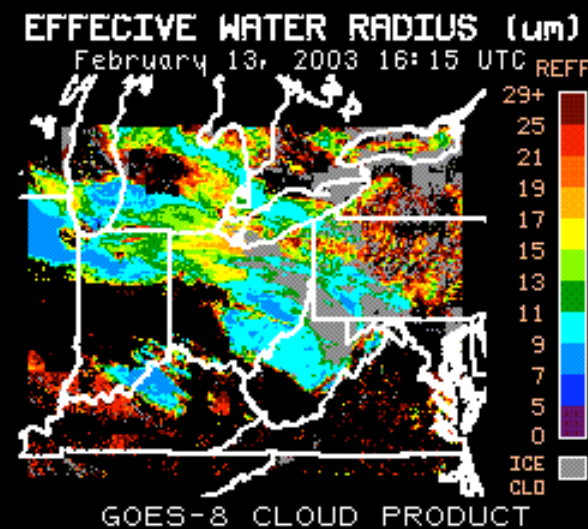
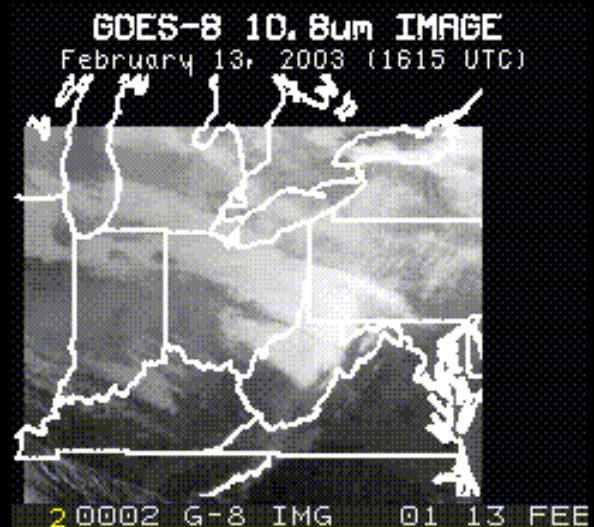
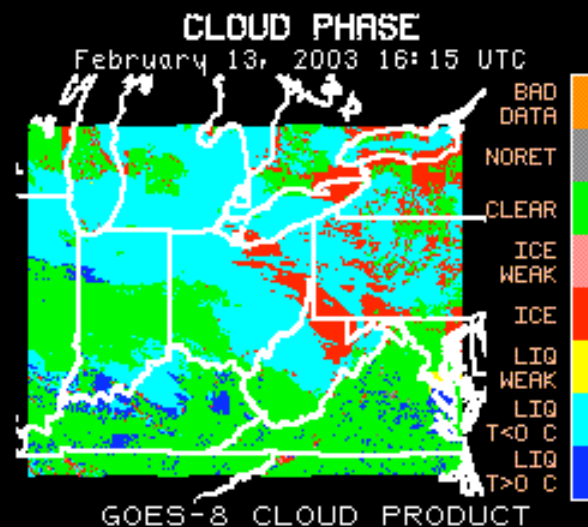
## Optical depth

$\tau = 32, 64, 96, 128, 12$

Reflectance  
ratio  
corresponding  
to Twin Otter  
flight on Feb  
13, 2003







# Motivation

- Use of reflectance techniques provides complimentary information to GOES emission-based technique currently used for phase determination by IIDA
- Geographic coverage of polar orbiters extends utility of satellite-based phase retrieval methods to high latitudes